SENTECH, INC.

Distributed Generation: Its Role in Emerging Economies

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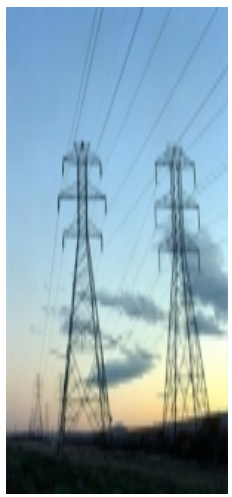
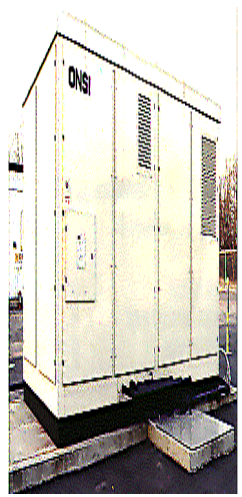


Discussion Topics

– Definition of Distributed Resources

– Benefits

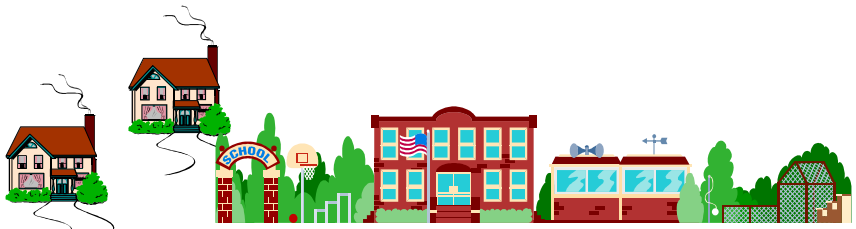
– Technology Options

– Markets and Market Barriers

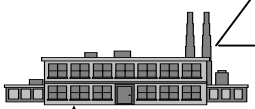
– Case Studies

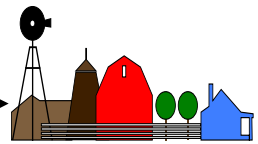
Distributed Generation- Definition

- Distributed generation is defined as “retail power” sited either on or in close proximity to the end-user.
- Located on “Power Distribution System”.
- Potential size varies from 5 kW to 50 MW.
- Distributed Resources includes both distributed generation and the enabling technologies which provide for the integration, communication and control of the asset in electrical distribution systems.

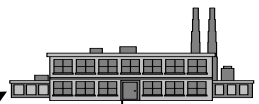


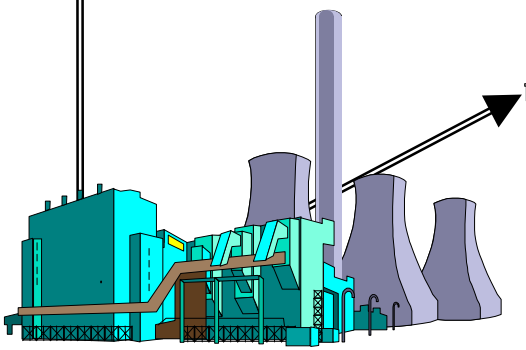
Substation

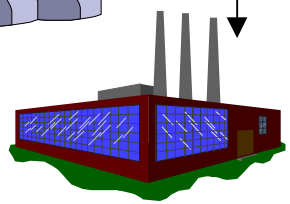




Substation

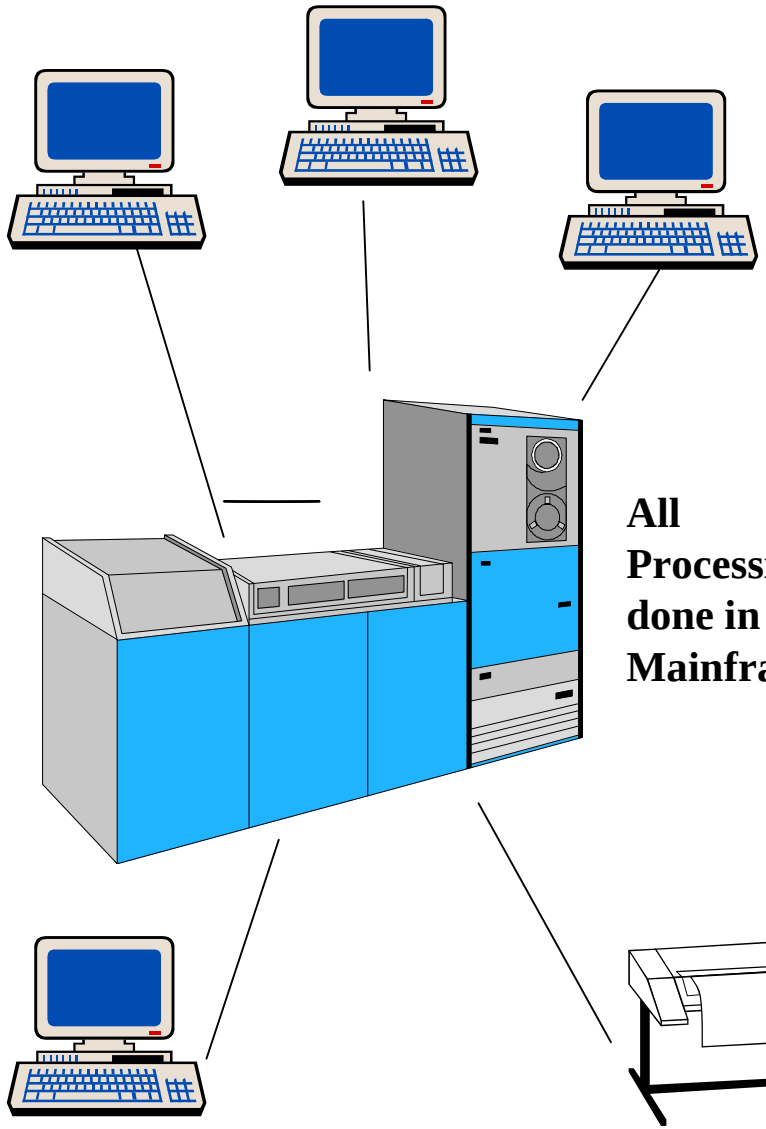






Power Plant

CENTRAL STATION



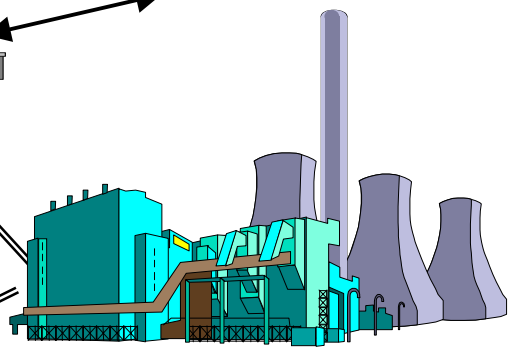
All Processing done in Mainframe

MAINFRAME/TERMINAL (TIMESHARE)

DR

Substation

Transmission line

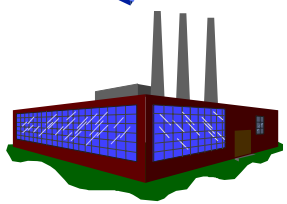


Power Plant

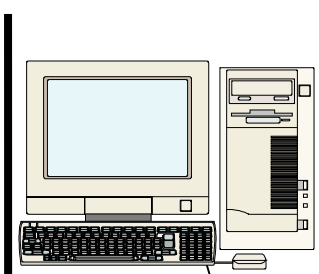
Substation

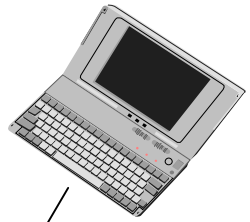
DR

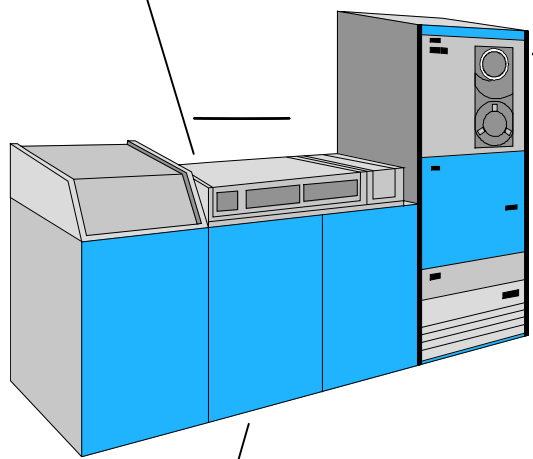
DR



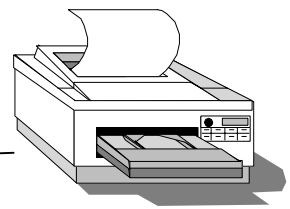
DISTRIBUTED GRID



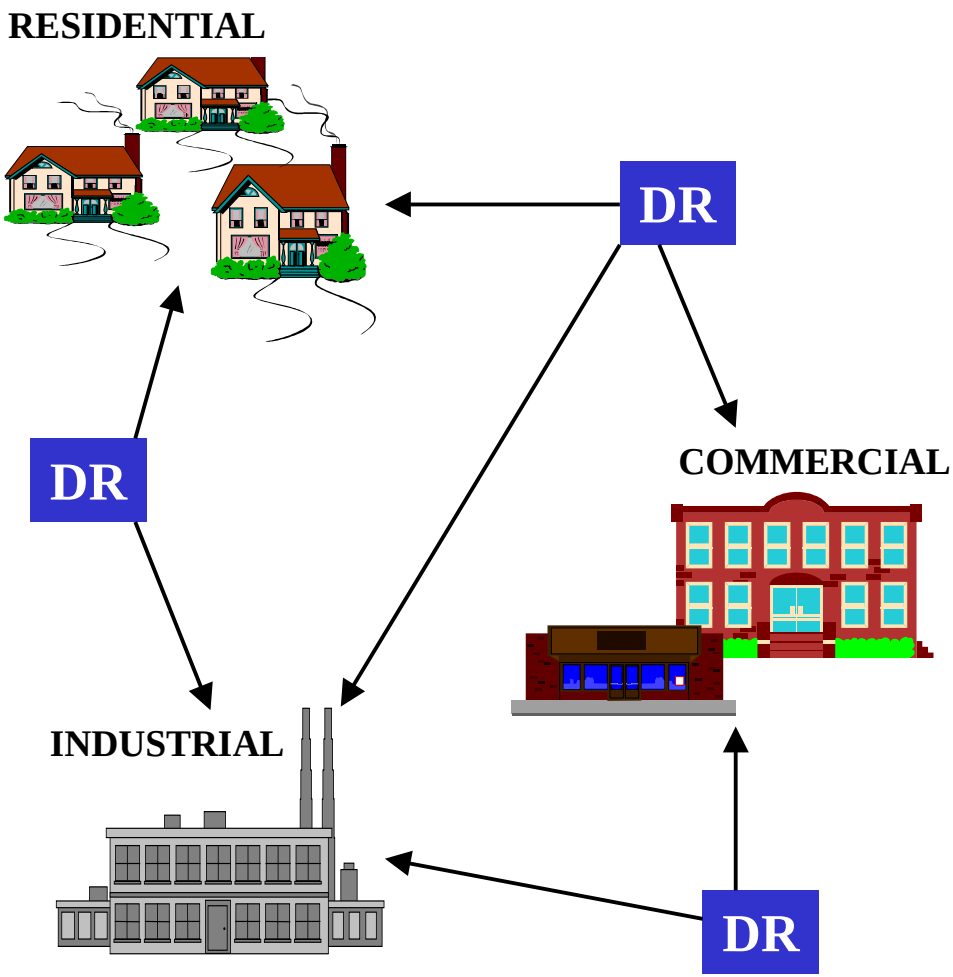




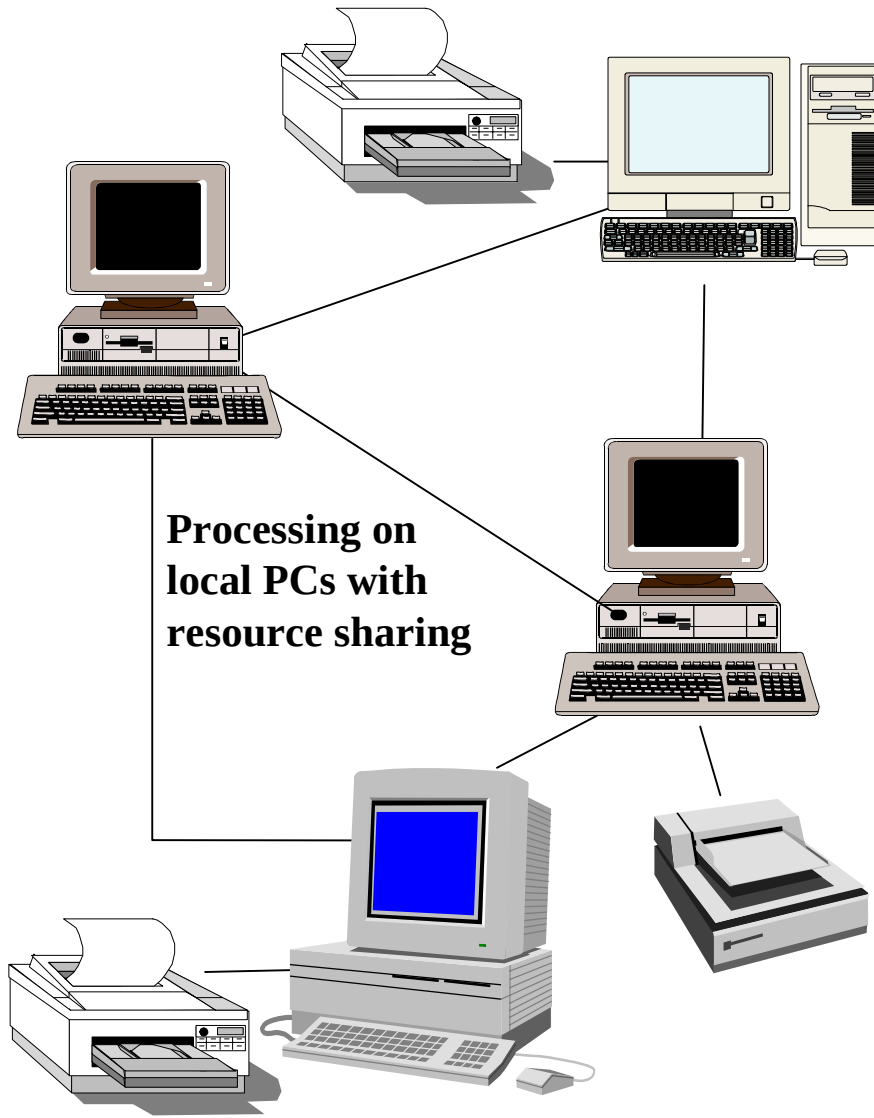
Processing on both server and local PCs



CLIENT SERVER LAN (INTRANET)



MICROGRID



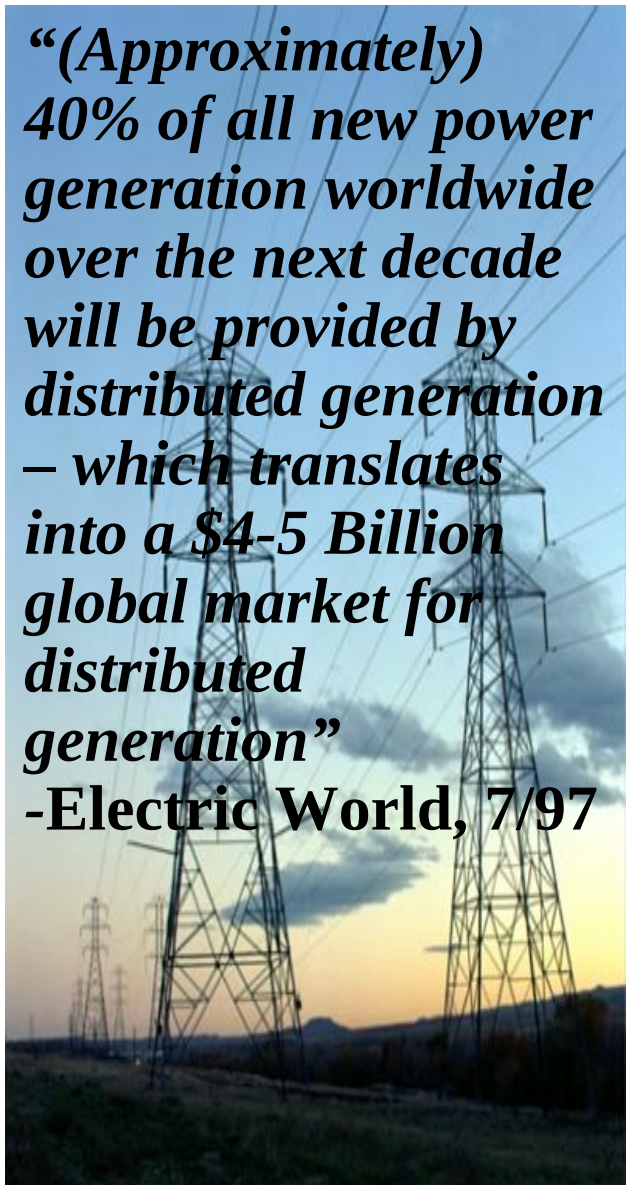
PEER TO PEER LAN

Distributed Generation- Benefits

- **Modular**
  - Flexible
  - Low construction lead time
- **Multi-Development Pathways**
  - Stand-alone operation
  - Micro-grids/ Village Power
  - Interconnected micro-grids
  - Interconnected grids
- **Reliability/Power Quality**
- **Energy Efficient**
- **Reduced Emissions**

Distributed Generation Options

Type	Size	Efficiency %	Market & Application
Reciprocating engines (Diesel engines)	50 kW- 6 MW	33-37	Standby power for commercial & industrial customers Load management
Combined heat and Power	5kW-100 MW	40-80	Industrial co generation for Hot Water, Space Heating, Industrial Processes
Micro-turbines	25 kW- 300 kW	20-30	Standby power, commercial cogeneration & chillers Peak shaving, off grid power
PAFC	50 kW- 1 MW	40	Commercial cogeneration Premium power
SOFC	5 kW- 3 MW	45-65	Commercial & industrial cogeneration Premium power, prime power
PEMFC	<1 kW- 1 MW	36-34	Premium power Off gird power
PV	<1 kW- 1 MW	10-20	Premium power, Off-grid power Green pricing
Hybrid Renewable	<1 kW- 1 MW	40-50	Premium power, Off-grid power Green pricing
Energy Storage	500-5000 kWh	70-80	Power Quality Peak shaving



Key Markets

- Reliability
- Power Quality
- Customer Side Peak Shaving
- Mini-and micro-grids

Key Drivers

- Electricity Restructuring
- Economic Development
- Air Emissions

Domestic Markets

— The "Annual Energy Outlook 2000" forecasts 300,000 MW of capacity additions in the US by 2020.

— The Consortium for Electric Reliability Technology Solutions (CERTS), in a recent white paper, estimates that 15-20% of the new capacity needs can be met with distributed resources.

Based on these two reports the market for DR in the US can be as much as 30,000 MW by 2010, and 60,000 Mw by 2020.

International Markets

— Global electric generating capacity is expected to increase by 50% in the next 20 years

— "International Energy Outlook 1999" projects that almost 7 million MW of new generating capacity will be required to meet electricity demand by 2020.

The international DR market can be over 1 million MW by 2020, assuming a 15% market share

Barriers to Market Development

- Fear of Change
- Lack of End-User Knowledge
- Lack of Market Conditioning
- Cost and Development Status

Mitigating Market Barriers

User Input

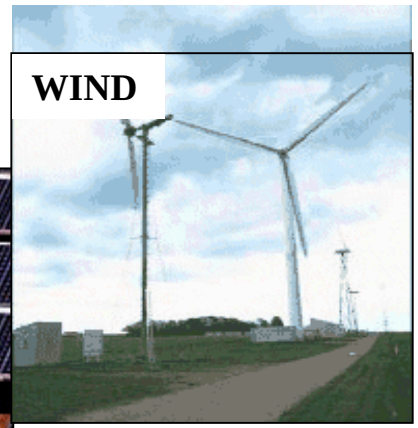
Generating Characteristics

Performance Calculations

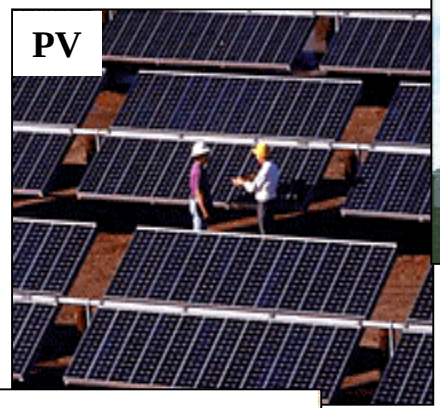
Economic Calculations

Results

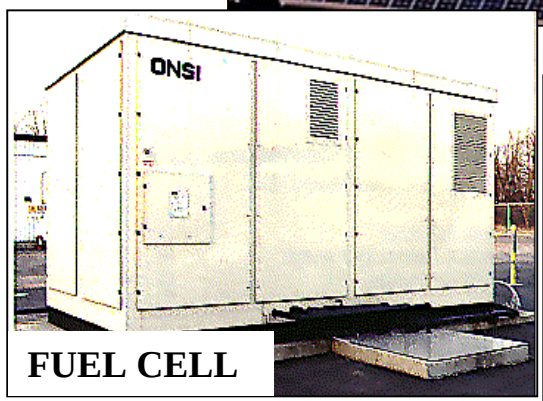
MICROTURBINE



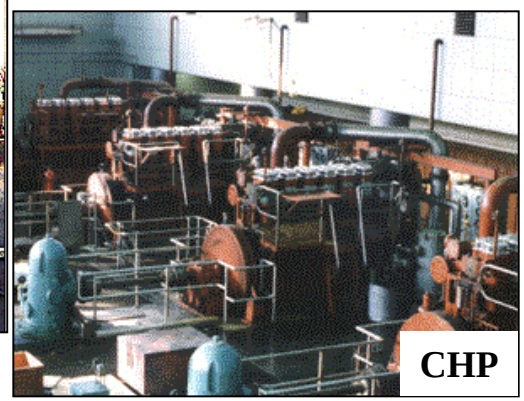
WIND



PV

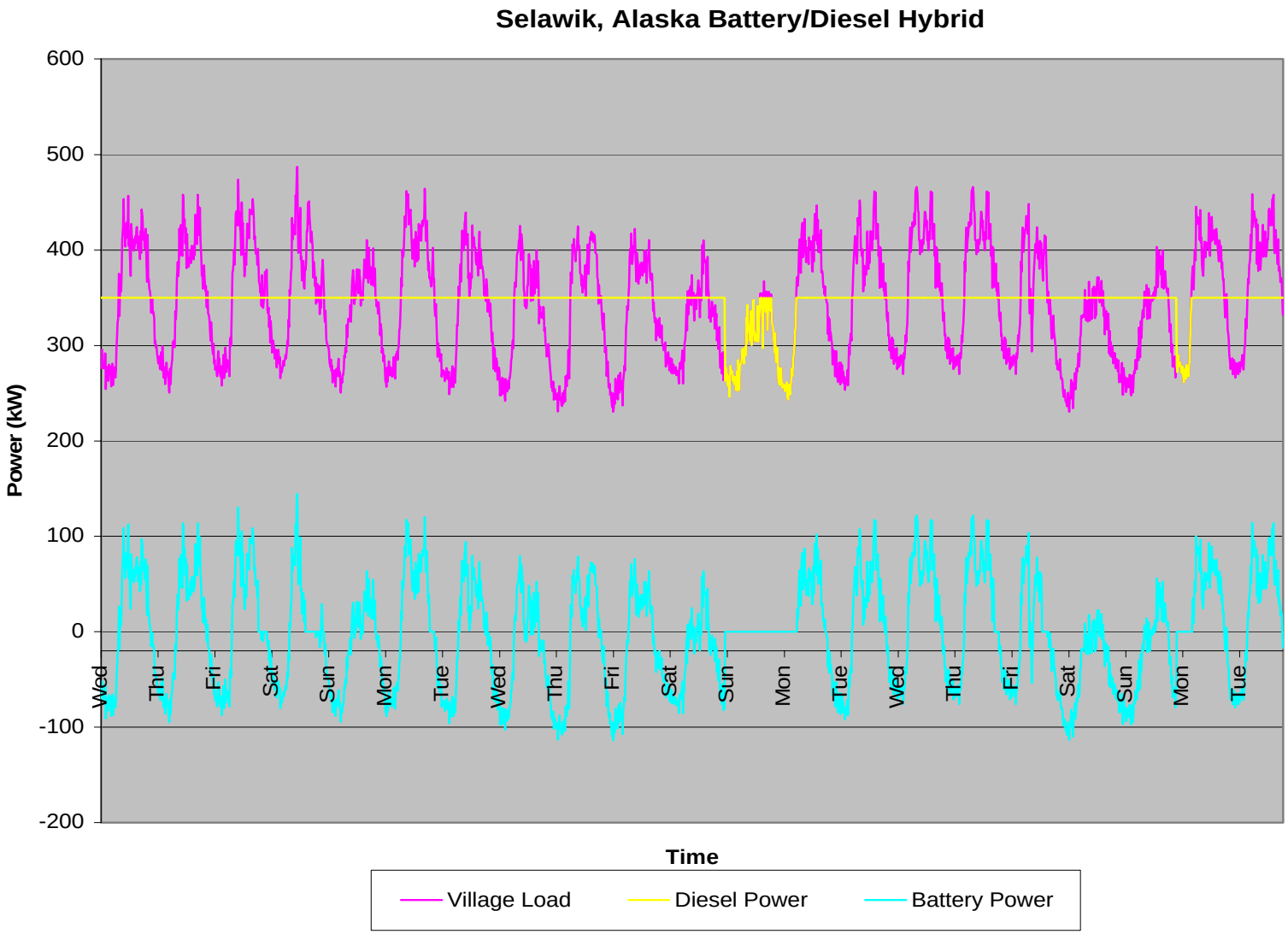


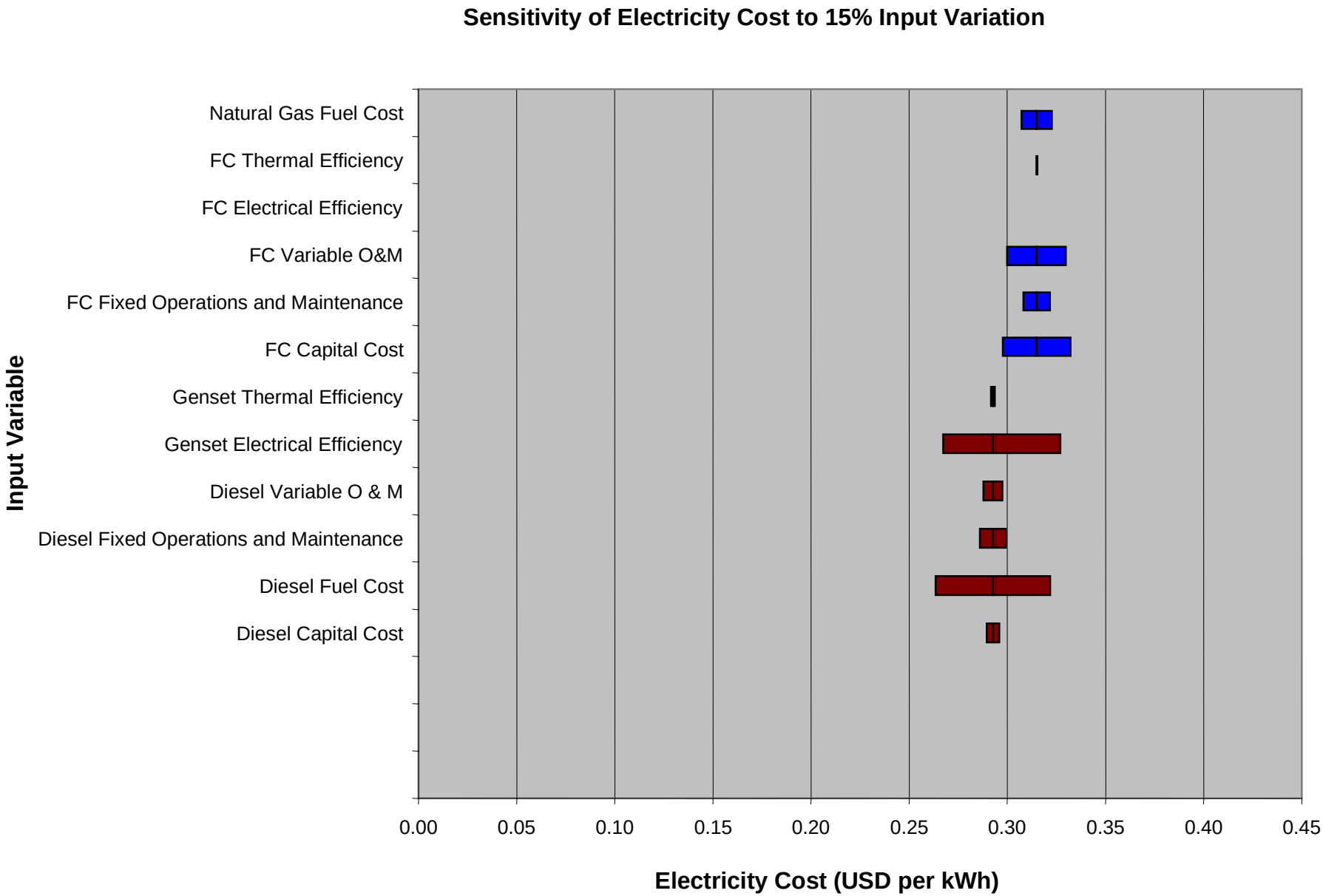
FUEL CELL



CHP

Alaska Diesel Battery Hybrid Results




Sensitivity of Electricity Cost to 15% Input Variation
Natural Gas Fuel Cost
FC Thermal Efficiency
FC Electrical Efficiency
FC Variable O&M
FC Fixed Operations and Maintenance
FC Capital Cost
Genset Thermal Efficiency
Genset Electrical Efficiency
Diesel Variable O & M
Diesel Fixed Operations and Maintenance
Diesel Fuel Cost
Diesel Capital Cost
Input Variable
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Electricity Cost (USD per kWh)

Philippine Fuel Cell Model Results

- **Cost of fuel cell derived electricity is higher**
- **Diesel fuel prices have to rise 31% to be cost competitive in today's market**
- **Delivered fuel cell cost of energy not including waste heat: 0.32 USD/kWh (using NG)**
- **Delivered diesel cost of energy: 0.29 USD/kWh**
- **Full waste heat utilization makes fuel cell competitive with diesel**
- **Diesel system much more sensitive to fuel price swings than fuel cell**